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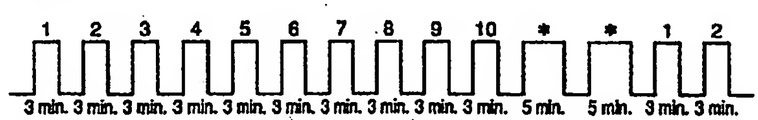
(54) Air conditioner

(57) In order to stabilize room temperature by adjusting heating capability, intermittent operation of a compressor 1 is performed with operation time of compressor 1 temporarily made longer at a prescribed timing, so that determination as to whether outdoor heat exchanger 5 is frosted or not can be made with high accuracy. Therefore, idle defrosting operation is prevented and defrosting operation is performed without fail when necessary. Therefore, heating efficiency is improved.

FIG.5



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an air conditioner. More specifically, the present invention relates to an air conditioner having a heating function ensuring room temperature stabilized near a set temperature.

Description of the Background Art

[0002] Conventionally, it has been known that a heat exchanger of an outdoor unit of an air conditioner is frosted, when the air conditioner is operated for heating. The reason for this is as follows. In the heating operation, the heat exchanger of the outdoor unit serves as an evaporator. The temperature of evaporation lowers as the outdoor air temperature lowers. Water in the air turns to water drop when it touches an object of which temperature is not higher than the dew point. Generally, when the outdoor temperature attains 5°C or lower, the evaporation temperature at the time of heating operation would be -5 to -10°C, and water in the air in contact with the heat exchanger of the outdoor unit frosts on the surface of the heat exchanger. Once frosted, the amount of air passing through the unit reduces, lowering efficiency of heat transfer, and therefore the evaporation temperature further lowers. This further promotes frosting of the heat exchanger of the outdoor unit. This causes decreased heating capability. Therefore, it is necessary to detect frosting and to defrost appropriately.

[0003] More specifically, when the outdoor heat exchanger is fully covered by the frost and the function of heat exchange is totally lost, the refrigerant, which should be turned to gas as it passes through the outdoor heat exchanger proceeds to the compressor in the form of the liquid. Therefore, liquid is accumulated at the accumulator, and the gas phase refrigerant only is absorbed by the compressor. If the liquid refrigerant exceeds the capacity of the accumulator, the liquid refrigerant goes to the compressor, possibly resulting in liquid compression, which may damage the compressor.

[0004] Accordingly, an air conditioner generally includes a defrosting determining circuit detecting whether a heat exchanger of an outdoor unit is frosted or not, and the air conditioner has a function of defrosting operation for defrosting the heat exchanger of the outdoor unit, if it is determined by the defrosting determining circuit that defrosting is necessary.

[0005] It should be noted, here, that the capability of heating lowers at the time of defrosting operation. Therefore, defrosting operation when the heat exchanger of the outdoor unit is not frosted, that is, a so-called idle defrosting operation, must be avoided. This requires the defrosting determining circuit to determine whether defrosting is necessary or not with high accuracy. In a general air conditioner, whether defrosting is necessary or not is determined using various factors including temperatures of the heat exchangers of the indoor unit and the outdoor unit, the outdoor air temperature, an duration of operation. As to the temperature of the heat exchanger of the outdoor unit, the temperature is monitored over at least 6 minutes after the start of operation of a compressor, so as to improve accuracy in determining the necessity of defrosting.

[0006] Non-inverter type air conditioners in which capability of compressing of a compressor is made constant, and inverter type air conditioners in which the capability of the compressor is variable have been proposed. In a non-inverter type air conditioner, when the room temperature attains close to a set temperature after the start of heating operation, the capability of heating is adjusted by intermittent operation of the compressor, so that the room temperature is stabilized near the set temperature. Here, the time of operation and the time of rest of the compressing function in the intermittent operation should be short to make the room temperature stable. When operation of the compressor is once stopped and re-started before refrigerant pressure is balanced to some extent, a large load is applied thereon, possibly causing damage. Therefore, operation of the compressor must not be re-started unless the refrigerant pressure is balanced to some extent.

[0007] In a general compressor, it is said that about three minutes is necessary until the refrigerant pressure is balanced to some extent after the operation of the compressor is stopped. For this reason, the operation is re-started after a so-called three-minutes-delay. Accordingly, in the conventional non-inverter type air conditioner, the rest time and operation time of the compressor in the intermittent operation are, in most cases, set to three minutes, so as to stabilize the room temperature.

[0008] In a non-inverter type air conditioner, an electronic control circuit is not provided on the outdoor unit, but on the indoor unit. Therefore, if the temperature of the outdoor heat exchanger is to be measured for determining the necessity of defrosting, for example, interconnection between the indoor and the outdoor units becomes complicated. Accordingly, the measurement is not performed, and necessity of defrosting is determined by measuring the temperature of the indoor heat exchanger.

[0009] As described, for example, in Japanese Patent Publication No. 58-32296, when the quantity of heat absorbed from the outside air by the outdoor heat exchanger lowers because of the frost, the temperature of the indoor heat exchanger lowers and the heating capability lowers naturally, and noting this phenomenon, defrosting operation is started when the temperature of the indoor heat exchanger attains not higher by a prescribed value than the temperature of the air absorbed

by the indoor heat exchanger.

[0010] Further, as described in Japanese Patent Laying-Open Nos. 62-206336 and 63-15020, when the outdoor heat exchanger is fully covered by the frost, the temperature of the refrigerant is not different at the entrance and at a middle portion of the indoor heat exchanger, and when there is no frost, the temperature of the refrigerant is higher at the entrance than at the middle portion, and noting this phenomenon, when, after a prescribed time period from the start of operation of the compressor, the temperature of a pipe coupled to the entrance of the refrigerant to the indoor heat exchanger is detected to be lower than the temperatures at various portions set corresponding to the amount of air of the indoor blower, the operation is switched to the defrosting operation.

[0011] Further, in some air conditioners, after a prescribed time period from the start of heating operation of the compressor, and after a prescribed time period from the detection that the temperature of a pipe coupled to the entrance of the refrigerant of the indoor heat exchanger becomes lower than a first prescribed temperature, when it is detected that the pipe temperature attained lower than a second prescribed temperature, the operation is switched to the defrosting operation.

[0012] For highly accurate determination of the necessity of defrosting, it is necessary to wait until the temperature of the heat exchanger through which the refrigerant started to flow by the operation of the compressor is stabilized. Generally, it takes about four minutes until the temperature of the heat exchanger becomes stable. Therefore, the time of about five minutes has been necessary after the start of operation of the compressor, in order to determine whether defrosting is necessary or not with high accuracy, as described above. In other words, highly accurate determination of defrosting is not possible during the intermittent operation in which the operation time of the compressor is three minutes. This has lead to the idle defrosting operation, or failure of defrosting operation when needed.

[0013] In the inverter type air conditioner, when the room temperature attains close to the set temperature after the start of heating operation, the capability of heating is adjusted by reducing driving power (driving energy: driving power supply frequency • voltage) supplied to the compressor, so as to stabilize the room temperature near the set temperature, and thus the room temperature is controlled to be stable around the set temperature. When the heating capability is excessively high even with the lowest driving energy supplied to the compressor and the room temperature continues to rise, the intermittent operation of the compressor takes place in the similar manner as in the non-inverter type air conditioner, so that the room temperature is adjusted to the set temperature. Namely, the intermittent operation of the compressor is performed to keep the room temperature stabilized near the set temperature in the inverter type air conditioner as well. In this intermittent operation, highly accurate determination of the necessity of the defrosting is impossible, as described above. Therefore, here again, the problem of idle defrosting operation or failure of defrosting operation when needed exists.

[0014] In the inverter type air conditioner, an electronic control circuit is provided in the outdoor unit for controlling power supply to the compressor (power supply frequency • voltage). Therefore, the temperature of the outdoor heat exchanger and the temperature of the outside air are measured, and if the temperature of the outdoor heat exchanger is not higher than the outdoor temperature by a prescribed value, it is determined that defrosting operation is necessary. For measuring the temperature of the outdoor heat exchanger, it is a prerequisite condition that a prescribed time period has passed from the start of operation of the compressor so that the temperature of the heat exchanger dependent on the refrigerant is made stable.

SUMMARY OF THE INVENTION

[0015] Therefore, an object of the present invention is to provide an air conditioner capable of determining whether a heat exchanger of an outdoor unit is frosted or not with high accuracy, preventing idle defrosting operation, and improving heating efficiency by surely performing defrosting operation when necessary.

[0016] Briefly stated, in the present invention, a first heat exchanger is provided indoors, a second heat exchanger is provided outdoors, the room temperature is detected by a room temperature detecting circuit and the room temperature is set by a temperature setting circuit. A refrigerant is circulated through the first and second heat exchangers by means of a compressor, and defrosting means performs defrosting operation to remove frost on the second heat exchanger. Power supply to the compressor is controlled based on the detected room temperature and the set temperature, and the power supplied to the compressor is increased temporarily at a prescribed timing.

[0017] Therefore, according to the present invention, the power supplied to the compressor is increased temporarily at a predetermined timing, and therefore, determination as to whether defrosting of the second heat exchanger is necessary or not in that period can be performed with high accuracy.

[0018] Further, as a large driving force is applied as a result to the compressor, when the second heat exchanger is in such a state that is about to require defrosting, the state can be immediately forced to the state requiring defrosting. This means that operation time in such a state that is about to require defrosting of the second heat exchanger can be reduced, and operation efficiency of the air conditioner can be improved. This reduces running cost of the air conditioner, and contributes to prevention of green house effect. Further, as the determination as to whether defrosting is neces-

sary or not is made with high accuracy, the reference for determining necessity of defrosting can be set more exactly. Therefore, possibility of idle defrosting operation can further be reduced.

[0019] Preferably, whether defrosting is necessary or not is determined when the driving power is changed, and if it is determined that defrosting is necessary, defrosting is done by the defrosting means.

[0020] Further, more preferably, intermittent operation is performed in which the compressor is operated continuously until the detected temperature attains close to the set temperature and driving and rest of the compressor are repeated as the temperature attains nearer, and at a predetermined timing, the driving time of the compressor in the intermittent operation is changed to a pre-set time, regardless of the set temperature and the temperature detected during the intermittent operation.

[0021] More preferably, the driving time is changed when a prescribed time has passed from the start of the intermittent operation.

[0022] More preferably, the driving time is changed when the number of repetition of the driving and rest of the compressor attains a predetermined number.

[0023] More preferably, the intermittent operation with the driving time changed is repeated for a predetermined number of times, and intermittent operation based on the detected temperature and the set temperature is resumed.

[0024] More preferably, outdoor air temperature detecting means for detecting outdoor air temperature is provided, and when the detected outdoor air temperature is not lower than a predetermined temperature, change in the driving time is inhibited.

[0025] More preferably, the magnitude of power supplied to the compressor is changed when a predetermined time period has passed from the start of operation of the compressor.

[0026] More preferably, outdoor air temperature is detected, and when the detected outdoor temperature is not lower than a predetermined temperature, change in the magnitude of the driving power is inhibited.

[0027] More preferably, the compressor is driven by an induction motor or a DC motor. [redacted] and when driven with the DC motor, the voltage or on/off duty ratio of the driving voltage is changed.

[0028] The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Fig. 1 is a block diagram representing a configuration of an air conditioner in accordance with one embodiment of the present invention.

Fig. 2 is a block diagram of a control circuit to which one embodiment of the present invention is applied.

Fig. 3 is a flow chart representing a specific operation of one embodiment of the present invention.

Fig. 4 is an illustration related to the defrosting operation in accordance with one embodiment of the present invention.

Fig. 5 represents operation cycles of the heating operation of the air conditioner in accordance with one embodiment of the present invention.

Fig. 6 is an illustration showing the state of operation in the intermittent operation of the air conditioner in accordance with one embodiment of the present invention.

Fig. 7 is a block diagram of a control circuit in accordance with another embodiment of the present invention.

Fig. 8 is an illustration related to the defrosting operation in accordance with another embodiment of the present invention.

Fig. 9 shows the state of operation of the heating operation of the air conditioner in accordance with another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] The air conditioner shown in Fig. 1 is of the non-inverter type, including an outdoor unit A and an indoor unit B. Outdoor unit A is provided with a compressor 1, a four way switching valve 2, a decompressor 4, an outdoor heat exchanger 5 and an outdoor blower 8. Indoor unit B is provided with an indoor heat exchanger 3, an indoor air temperature sensor 6 and an indoor blower 7. Indoor unit B is connected to the mains, and power is supplied to the indoor unit A through an indoor • outdoor interconnection. On the side of indoor unit A, current consumption at compressor 1 is detected by current detecting means 9. A thermistor for temperature detection, a control circuit and the like are provided on the outdoor unit A for measuring the temperature of the outdoor heat exchanger.

[0031] In the air conditioner shown in Fig. 1, a refrigerating cycle is formed by successively linking compressor 1, four way switching valve 2, indoor heat exchanger 3, decompressor 4 and outdoor heat exchanger 5. The refrigerant from compressor 1 is switched by four way switching valve 2, and at the time of cooling operation, the refrigerant from compressor 1 is condensed by outdoor heat exchanger 5, radiated to the atmosphere, the refrigerant is expanded through decompressor 4 and indoor heat exchanger 3 so that the air in the room is cooled, and the refrigerant is returned to the compressor 1 through the four way switching valve 2, as shown by the solid arrows in Fig. 1.

[0032] In the heating operation, the refrigerant from compressor 1 is condensed by indoor heat exchanger 3 and the air in the room is heated, the refrigerant is expanded and evaporated through decompressor 4 and outdoor heat exchanger 5, heat is supplied from the outdoor air, and the refrigerant returns to the compressor 1 through four way switching valve 2, as shown by dotted arrows in Fig. 1.

[0033] Fig. 2 is a block diagram of a control circuit in accordance with one embodiment of the present invention. Referring to Fig. 2, the control circuit includes a control unit 10 for the indoor unit B and a control unit 20 for the outdoor unit A. Control units 10 and 20 are implemented by a microprocessor, for example. To control unit 10, an output of a room temperature detecting circuit 11 and an output of a room temperature setting circuit 12 are applied. To control unit 20, an output of a current detecting circuit 21, an output of a circuit 25 for detecting the temperature of the outdoor heat exchanger and on output of a circuit for detecting outdoor temperature are provided. Control unit 10 applies a control signal to a switching element 13 for the indoor blower, and control unit 20 applies control signals to a four way switching valve relay 22, an indoor blower relay 23, and a compressor relay 24, respectively.

[0034] Temperature detecting circuit 11 detects room temperature based on an output of room temperature sensor 6, shown in Fig. 1 and applies the detected output to control unit 10. Temperature setting circuit 12 sets the indoor temperature. Control unit 10 determines the difference between the detection output from room temperature detecting circuit 11 and the set temperature set by temperature setting circuit 12, and outputs a determination signal to control unit 20.

[0035] Current detecting circuit 21 detects current consumption based on an output of current detecting means 9 provided in outdoor unit A shown in Fig. 1, and applies it to control unit 20. The circuit 25 for detecting the temperature of the outdoor heat exchanger detects the temperature of the outdoor heat exchanger 5 shown in Fig. 1, and the circuit 26 for detecting the outdoor temperature detects the outdoor temperature. In the present embodiment, based on the temperature detected by the circuit 25 for detecting the temperature of the outdoor heat exchanger and the temperature detected by the circuit 26 for detecting the outdoor temperature, whether outdoor heat exchanger 5 is frosted or not is determined. The defrosting operation is performed by switching the four-way valve to the cooling cycle, and causing hot gas from compressor 1 to flow to outdoor heat exchanger 5, that is, the so called reverse defrosting.

[0036] Control unit 10 controls indoor blower 7 through switching element 13 for the indoor blower, control unit 20 controls four-way valve 2 through four-way valve relay 22, controls outdoor blower 8 through outdoor blower relay 23, and controls compressor 1 through compressor relay 24.

[0037] Fig. 3 is a flow chart representing a specific operation of one embodiment of the present invention, Fig. 4 relates to the defrosting operation, Fig. 5 shows operation cycles in the intermittent operation of the compressor, and Fig. 6 shows the state of operation in the heating operation of the air conditioner.

[0038] Specific operation of one embodiment of the present invention will be described with reference to Figs. 1 to 6. In the following, only the operation in heating will be described. In the heating operation, control unit 10 determines the room temperature based on the detection output of room temperature detecting circuit 11 shown in Fig. 2.

[0039] Generally, a wall hanging type indoor unit B of the air conditioner is placed near the ceiling where warm air gathers. Therefore, the temperature detected by room temperature sensor 6 is not regarded as the room temperature in the air conditioner in accordance with the present embodiment. Control unit 10 applies a control signal to control unit 20 based on the difference between the set temperature set by temperature setting circuit 12 and the temperature detected by room temperature sensor 6, and control unit 20 controls compressor 1.

[0040] More specifically, compressor operates continuously until the measured temperature exceeds the set temperature + 4°C, as shown in Fig.6, and when the room temperature increases and exceeds the set temperature + 4°C, the compressor is switched to the first intermittent operation mode in which three minutes of operation/three minutes of rest is repeated. When the room temperature further increases and exceeds the set temperature + 6°C, the compressor is switched to the second intermittent operation mode in which three minutes of operation/eight minutes of rest is repeated. When the room temperature further increases and exceeds the set temperature + 9°C, the operation of the compressor 1 is stopped. In such cycles of heating operation, the defrosting operation, which will be described in the following, takes place. The flow chart of Fig. 3 schematically shows the defrosting operation in a certain cycle during the heating operation.

[0041] The defrosting operation in a certain cycle during the heating operation will be described. In step (in the figure, simply represented by SP) SP1 of Fig. 3, the heating operation is performed, in step SP 2, whether the detected room temperature exceeded the set temperature +4°C (measured temperature - set temperature = 4°C) in the state of operation shown in Fig. 6 is determined, and if not exceeded, compressor relay 24 is turned and kept on by control unit 20 for continuous operation in step SP3, and power is continuously supplied to compressor 1. Control units 10 and 20 repeat the operations of steps SP2 and SP3 so as to operate compressor 1 continuously, whereby room temperature increases.

[0042] When it is determined by control unit 10 that the measured room temperature has exceeded set tem-

perature +4°C in step SP2, control unit 20 switches compressor 1 to first intermittent operation mode in which the compressor 1 is operated repeatedly in the cycle of three minutes of operation/three minutes of rest, by means of compressor relay 24. Control unit 20 determines in step SP5 whether the first intermittent operation mode is repeated ten times or not. By repeating the operations of steps SP4 and SP5, compressor 1 repeats three minutes of operation and three minutes of rest repeatedly for ten times, as shown in Fig. 5, when the measured room temperature is +4°C to +6°C higher than the set temperature. The room temperature is constantly detected, and the operation mode (continuous operation ~ intermittent operation ~ rest) is switched based on the relation with the set temperature, as represented in Fig. 6.

[0043] In step SP5, when control unit 20 determines that the first intermittent operation mode of three minutes of operation and three minutes of rest is repeated ten times under condition of the set temperature and the detected temperature (Fig. 6), compressor relay 24 is turned on, so as to temporarily perform intermittent operation in which the operation time of compressor 1 is extended to five minutes in step SP6. More specifically, it is not possible to determine whether defrosting is necessary or not with high accuracy in the intermittent operation of three minutes of operation and three minutes of rest, as described above. Therefore, after ten times of intermittent operation of three minutes of operation and three minutes of rest of the compressor 1, the operation time of compressor 1 is extended automatically to five minutes.

[0044] As the operation time of compressor 1 is extended to five minutes, it becomes possible to determine whether defrosting is necessary or not with high accuracy as the flow of refrigerant becomes stable, the temperature of the heat exchanger becomes stable and the measured temperature can be used reliably. Therefore, control unit 20 determines whether defrosting is necessary or not in step 7, near the end of the on time of five minutes. Further, by repeating twice the intermittent operation with the operation time of compressor 1 extended to five minutes, the following becomes possible. Namely, when the state of the outdoor heat exchanger 5 is in such a state that almost or about to require defrosting, the amount of frost on the outdoor heat exchanger 5 increases, and outdoor heat exchanger 5 quickly enters the state which requires defrosting. Determination as to whether defrosting is necessary or not is made based on whether the temperature of outdoor heat exchanger 5 and the outdoor air temperature are in the predetermined area requiring defrosting, as shown in Fig. 4.

[0045] In the conventional non-inverter type air conditioner, whether defrosting is necessary or not is determined by assuming frost on the outdoor heat exchanger based on the temperature of a pipe coupled to the refrigerant entrance to indoor heat exchanger 3. The determination of the necessity of defrosting, however, is not very exact in this method. Therefore, in the present embodiment, both the outdoor temperature and the temperature of the outdoor heat exchanger are measured as in the inverter type conditioner, for precise determination of defrosting.

[0046] The problem here is that the operation time of compressor 1 in the continuous operation is three minutes. Generally, the temperature of the outdoor heat exchanger is always measured during operation provided that accumulated operation time of compressor 1 exceeds 20 minutes (the accumulation time is cleared in the defrosting operation). At the start of operation, however, the temperature of the outdoor heat exchanger is not stable. Accordingly, when the temperature of the outdoor heat exchanger after four minutes from the start of operation of compressor 1 is kept for two minutes within the area requiring defrosting shown in Fig.4, which is determined by the outdoor temperature and the temperature of the outdoor heat exchanger, it is determined that defrosting is necessary.

[0047] In the intermittent operation, the operation time of the compressor is five minutes, and hence, when the temperature of the outdoor heat exchanger after three minutes from the start of operation of compressor is kept for two minutes within the area requiring defrosting, it is determined that defrosting is necessary.

[0048] When it is determined by control unit 20 that defrosting is necessary, defrosting operation is performed in step SP8. In heating operation, outdoor heat exchanger 5 serves as an evaporator. When the outdoor air temperature lowers and the evaporating temperature lowers, water in the air turns to water drop when it is in contact with an object of which temperature is not higher than the dew point. When the outdoor air temperature attains to be 5°C or lower, the evaporator in the heating operation would be -5°C to -10°C, and the water in the air in contact with outdoor heat exchanger 5 frosts on the surface, thus outdoor heat exchanger 5 is frosted.

[0049] Therefore, in the defrosting operation, the reverse cycle takes place. More specifically, during heating operation, the operation cycle is temporarily switched to a refrigerating cycle, so that outdoor heat exchanger 5 is used as a condenser to radiate heat, and thus the frost is eliminated. In this manner, by the two operations with the operation time of compressor 1 extended to five minutes, it is possible to reduce the operation time with the outdoor heat exchanger 5 being in the state about to require defrosting, and hence efficiency of heating by the air conditioner is improved. This reduces running cost of the whole apparatus (reduction in power consumption), and in addition, provides the effect of preventing green house effect (reduction of CO_2 exhaustion amount).

[0050] Control unit 20 determines in step SP9 whether the detected temperature exceeds the set temperature +6°C (measured temperature - set tempera-

ture =6°C). If it is YES, compressor relay 24 is turned and kept on for three minutes and turned and kept off for eight minutes, so as to switch operation mode to a second intermittent operation mode in which the compressor 1 is repeatedly operated with three minutes of operation and eight minutes of rest, in step SP 12. In step SP13, control unit 20 determines whether the cycle of three minutes of operation and eight minutes of rest of the second intermittent operation mode has been repeated ten times, and when it is determined that the operation has been repeated ten times, the intermittent operation with the operation time of compressor 1 extended to five minutes is repeated twice in step SP14. Similar to the step SP7 described above, whether defrosting is necessary or not is determined in step SP15 near the end of the on time of five minutes, and if it is necessary, defrosting operation is performed in step SP16.

[0051] Control unit 10 determines whether the temperature exceeds set temperature +9°C (measured temperature - set temperature =9°C) in step SP10 as the room temperature increases by the second intermittent operation mode, and if control unit 10 determines it is, control unit 20 stops power supply to compressor 1 through compressor relay 24.

[0052] When the intermittent operation with the operation time of compressor 1 extended to five minutes is repeated twice in steps SP6 and SP14, control unit 20 performs the original intermittent operation with the operation time of compressor 1 returned to three minutes, the intermittent operation with the operation time of compressor 1 being three minutes is repeated ten times, thereafter the intermittent operation with the operation time of compressor 1 extended to five minutes is again repeated twice, and determination as to whether defrosting of outdoor heat exchanger 5 is necessary or not is made in steps SP7 and SP15.

[0053] If the air conditioner of the present embodiment, when the outdoor air temperature is higher than a prescribed temperature, control unit 20 inhibits the intermittent operation with the operation time of compressor 1 extended to five minutes. When the outdoor air temperature is relatively high, outdoor heat exchanger 5 is almost free from frost, and hence defrosting operation is unnecessary. Therefore, it is unnecessary to determine whether defrosting is necessary with the operation time of compressor 1 extended to five minutes. Therefore, the operation time of compressor 1 is not extended to five minutes, and the room temperature is stabilized near the set temperature by the normal three minutes of intermittent operation of the compressor 1.

[0054] In the foregoing, the control is for switching the operation mode as the temperature detected by the room temperature sensor 6 increases. The control when the detected temperature lowers is as follows. When the detected temperature lowers from set temperature +9°C (when the operation of compressor 1 is stopped) to be lower than the set temperature +9°C, control unit 10 operates the compressor 1, of which operation has been stopped, in the second intermittent operation mode of three minutes of operation/eight minutes of rest, in step SP12. If the temperature detected by temperature sensor 9 lowers and the detected temperature becomes lower than set temperature +6°C even in the second intermittent operation mode, control unit 10 switches the operation mode of compressor 1 to the first intermittent operation mode in which the compressor is repeatedly operated with three minutes of operation/three minutes of rest. If the temperature detected by temperature sensor 6 still lowers in the first intermittent operation mode and the detected temperature becomes lower than set temperature +3°C, control unit 10 switches the operation mode to continuous operation mode in which compressor 1 is operated continuously, in step SP3.

[0055] In this manner, in the air conditioner according to the present embodiment, control unit 10 switches the operation mode of compressor 1 based on the difference between the set temperature and the temperature detected by temperature sensor 6 to adjust the heating capability, so that the room temperature can be adjusted to be stable near the set temperature.

[0056] Though control unit 10 controls power supply to compressor 1 in accordance with the temperature detected by indoor temperature sensor 6 in the above described embodiment, the timing for switching the intermittent operation with the operation time of compressor 1 extended to five minutes may be switched dependent on the output of the circuit 26 for detecting the outdoor temperature. More specifically, the number of repetition of the intermittent operation of compressor 1, which determines the timing of intermittent operation with the operation time of compressor 1 extended to five minutes, may be reduced as the outdoor temperature becomes lower.

[0057] In the above described example, the intermittent operation with the operation time of compressor 1 extended to five minutes takes place after the operation/rest of compressor 1 is repeated ten times. When the outdoor temperature is relatively high, the intermittent operation with the operation time of compressor 1 extended to five minutes may be performed after the operation/rest of compressor 1 is repeated five times. More specifically, when it is more likely that heat exchanger 1 is frosted, the cycle for determining the necessity of the defrosting is made shorter, so that the operation time with the heat exchanger being in the state requiring defrosting can be reduced.

[0058] After entering the first intermittent operation mode, the temperature detected by temperature sensor 6 may possibly increase before the three minutes operation/three minutes of rest of compressor 1 is repeated ten times, and the operation mode is switched to the second intermittent operation mode. In such a case, the intermittent operation with the operation time of the compressor extended to five minutes may be performed

when three minutes of operation/eight minutes of rest of compressor 1 in the second intermittent operation mode is repeated ten times.

[0059] The intermittent operation with the operation time of compressor 1 extended to five minutes may be performed when the total of the intermittent operations of compressor 1 in the first and second intermittent operation modes reaches ten times.

[0060] Further, if the room temperature increases in the intermittent operation with the operation time of compressor 1 extended to five minutes, the rest time of compressor 1 may be extended from three to five or eight minutes, for example, so that the room temperature is kept stable also in the rest time of compressor 1.

[0061] Fig. 7 is a block diagram representing a configuration of an air conditioner in accordance with another embodiment of the present invention. In the embodiment shown in Figs. 1 to 6, the present invention has been applied to a non-inverter type air conditioner. The embodiment shown in Fig. 7 represents the present invention applied to an inverter type air conditioner.

[0062] In Fig. 7, control unit 10 for indoor unit B, room temperature detecting circuit 11, room temperature setting circuit 12, switching element 14 for the indoor blower, control unit 20 for the outdoor unit A, current detecting circuit 21, the circuit 25 for detecting the temperature of the outdoor heat exchanger, the circuit 26 for detecting outdoor temperature, four-way switching valve relay 22 and outdoor blower relay 23 are of the same configurations as those shown in Fig. 2. As the air conditioner is of the inverter type, a power supply control unit 30, a rectifier circuit 17, a booster circuit 18 and an inverter 19 are additionally provided. [redacted]

[0063] Fig. 8 is an illustration related to the defrosting operation in accordance with this another embodiment of the present invention, and Fig. 9 shows the state of operations in the heating operation of the air conditioner in accordance with this embodiment of the present invention.

[0064] In the present embodiment, the number of rotation of compressor 1 is controlled in accordance with temperature difference between the set temperature and the temperature detected by temperature sensor 6. More specifically, as the difference between the set temperature and the temperature detected by temperature sensor 9 increases as shown in Fig. 9, control unit 20 controls power supply control unit 30 so that the frequency from inverter 19 gradually lowers. As the frequency generated from inverter 19 lowers gradually, the number of rotation of compressor 1 becomes smaller from F6 → F5 → F4 → F3 → F2 → F1 (F6 > F5 > F4 > F3 > F2 > F1).

[0065] More specifically, when the detected temperature is lower than set temperature +1.5°C, the number of rotation of compressor 1 is set to F6. When the detected temperature is lower than set temperature +2°C, the number of rotation is set to F5. Similarly, when the detected temperature is lower than set temperature +4°C, the number of rotation of compressor 1 is set to F1, and the operation is continued. When the detected temperature is lower than set temperature +4°C, the first intermittent operation of three minutes of operation and three minutes of rest is performed. When the detected temperature is lower than set temperature +6°C, the number of rotation of compressor 1 is set to F1 and the second intermittent operation with three minutes of operation and eight minutes of rest is performed. When the second intermittent operation is repeated four times or when the detected temperature becomes not lower than set temperature +6°C, the operation of compressor 1 is stopped.

[0066] In the present embodiment also, when three minutes of operation and three minutes of rest of compressor 1 are repeated ten times in the first intermittent operation mode, the intermittent operation with the operation time of compressor 1 extended to five minutes is repeated twice. When the operation time of compressor 1 is extended to five minutes, whether defrosting of outdoor heat exchanger 5 is necessary or not is determined. If necessary, defrosting operation is performed. In the present embodiment, however, the air conditioner is of the inverter type. Therefore, the area requiring defrosting operation differs dependent on whether the frequency generated from inverter 19 is in a low frequency band or a high frequency band. Therefore, control unit 20 performs the defrosting operation dependent on whether the relation between the outdoor air temperature and the temperature of outdoor heat exchanger 5 is within the area requiring defrosting, determined by the frequency generated by inverter 19 as shown in Fig. 8. In Fig. 8, the defrosting area a is when the driving power supply frequency of compressor 1 is low, and defrosting area b is when the driving power supply frequency of compressor 1 is high.

[0067] Therefore, in the present embodiment also, necessity of defrosting of outdoor heat exchanger 5 is determined in the intermittent operation with the operation time of compressor 1 extended to five minutes. Therefore, as in the non-inverter type air conditioner, determination as to whether defrosting of outdoor heat exchanger 5 is necessary or not can be done with high accuracy.

[0068] In a general inverter type air conditioner, even when the operation mode is switched to the second intermittent operation, the room temperature lowers in a short time and the operation mode returns to the first intermittent operation, and hence operation of compressor 1 is in most cases not stopped (fully stopped).

[0069] In the air conditioner in accordance with the present embodiment, driving power supplied to compressor 1 is temporarily increased at every prescribed time period even in the continuous operation of compressor 1, so as to temporarily increase the heating capability and to increase the amount of frost adhered on outdoor heat exchange unit. As to the method of increasing driving power supplied to compressor 1, for example, compressor 1 may be continuously operated for 40 minutes with the driving frequency F1 and compressor 1 is operated with the number of operation F3 only for five minutes. Therefore, if the heat exchanger 5 is in such a state that almost requires defrosting, the heat exchanger immediately attains to the state requiring defrosting. Therefore, the operation time with the heat exchanger 5 being in the state almost requiring defrosting is made shorter, and operation efficiency of the air conditioner can be improved. This reduces running cost of the air conditioner as a whole, and further, it provides the effect of preventing green house effect (reduction of CO_2 exhaustion amount).

[0070] An induction motor or a DC motor may be used for compressor 1. Inverter 19 supplying power to the motor coil of compressor 1 from the DC power rectified by rectifier circuit 17 for each case will be described in the following.

[0071] [redacted], the driving frequency and the driving voltage are increased by the so-called PWM control of the inverter.

[0072] When a DC motor is used, in order to increase the number of rotation of compressor 1 and to improve heating capability, it is necessary to increase the power to be supplied to compressor 1. [redacted] compressor 1 is to be driven with higher voltage, the DC voltage is boosted by booster circuit 18. When compressor 1 is to be driven with lower power, duty ratio of on and off times may be changed by the inverter 19. Generally, the on/off frequency is selected to be 3kHz or 5kHz. Alternatively, power factor may be improved by PAM (Pulse Amplitude Modulation) control by booster circuit 18, so that the power supplied to compressor 1 is increased.

[0073] The PWM control and the PAM control in the inverter are well known techniques described, for example, in Japanese Patent Laying-Open Nos. 59-181973 and 6-105563. Therefore, detailed description thereof is not given here.

[0074] Further, in the above described embodiments, determination as to whether defrosting is necessary or not can be made with high accuracy. Therefore, the reference for determining necessity of defrosting can be set exactly, and hence possibility of idle defrosting operation can be reduced.

[0075] As described above, according to the embodiments of the present invention, even when the compressor is operated intermittently, the operation time of the compressor is set longer at a prescribed timing, and hence determination as to whether defrosting of heat exchanger is necessary or not can be made with accuracy even in the intermittent operation.

[0076] Further, as large driving force is applied as a result to the compressor, when the outdoor heat exchanger is in such a state that almost requires defrosting, the exchanger can be set quickly to the state which requires defrosting. Therefore, the operation time with the heat exchanger in the state almost requiring defrosting can be made shorter, and operation efficiency of the air conditioner can be improved. Further, as the determination of the necessity of defrosting can be made with high accuracy, the reference for determining necessity of defrosting can be set exactly, and hence possibility of idle defrosting can further be reduced.

[0077] Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

Claims

1. An air conditioner capable of heating operation, comprising:

   a first heat exchanger (3) provided indoors;
   a second heat exchanger (5) provided outdoors;
   room temperature detecting means (6) for detecting a room temperature;
   temperature setting means (12) for setting the room temperature;
   a compressor (1) for circulating a refrigerant to said first and second heat exchangers;
   defrosting means (1, 2, 3, 4, 5) for defrosting operation of said second heat exchanger, for removing frost attached to said second heat exchanger; and
   control means (10, 20) controlling power to be supplied to said compressor based on a temperature detected by said room temperature detecting means and the temperature set by said temperature setting means, so that the power supplied to said compressor is temporarily increased at a predetermined timing.

2. The air conditioner according to claim 1, wherein

said control means (10, 20) determines whether defrosting is necessary or not when said driving power is changed, and when it is determined that defrosting is necessary, operates said defrosting means for defrosting.

3. The air conditioner according to claim 1 or 2, wherein said control means continuously operates said compressor until said detected room temperature attains close to the set room temperature, performs intermittent operation in which driving and rest of said compressor are repeated when the detected temperature attains close to the set temperature, and during said intermittent operation, driving time of said compressor in said intermittent operation is changed to a preset time regardless of said detected room temperature and the set room temperature, at said predetermined timing.

4. The air conditioner according to claim 3, wherein

said control means changes said driving time, after a prescribed time period from the start of said intermittent operation.

5. The air conditioner according to claim 3, wherein

said control means changes said driving time when time of repetition of the driving and rest of said compressor reaches a predetermined number.

6. The air conditioner according to any of claims 1 to 5, wherein

said control means performs the intermittent operation with said driving time changed for a predetermined number of times, and returns to said intermittent operation based on said detected temperature and set temperature.

7. The air conditioner according to any of claims 1 to 6, further comprising

outdoor air temperature detecting means for detecting outdoor air temperature, wherein
said control means inhibits change of said driving time when the outdoor air temperature detected by said outdoor air temperature detecting means is not higher than a predetermined temperature.

8. The air conditioner according to claim 1, wherein said control means changes magnitude of power supplied to said compressor, after a prescribed time period from the start of operation of said compressor.

9. The air conditioner according to claim 8, wherein

outdoor air temperature detecting means for detecting outdoor air temperature, wherein
said control means inhibits change of said driving time when the outdoor air temperature detected by said outdoor air temperature detecting means is not higher than a predetermined temperature.

10. The air conditioner according to claim 8 or 9, wherein

[redacted]

11. The air conditioner according to claim 9 or 10, wherein

said compressor is driven by a DC motor, and said control means changes duty ratio of on and off or voltage of a driving power supply to said DC motor.

FIG.1

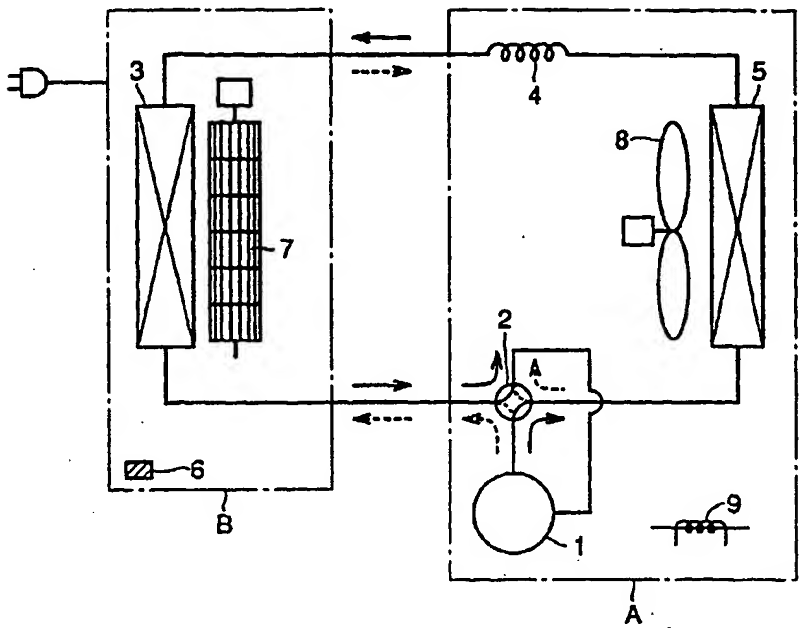

3
4
5
8
7
2
A
6
B
9
1
A

FIG.2

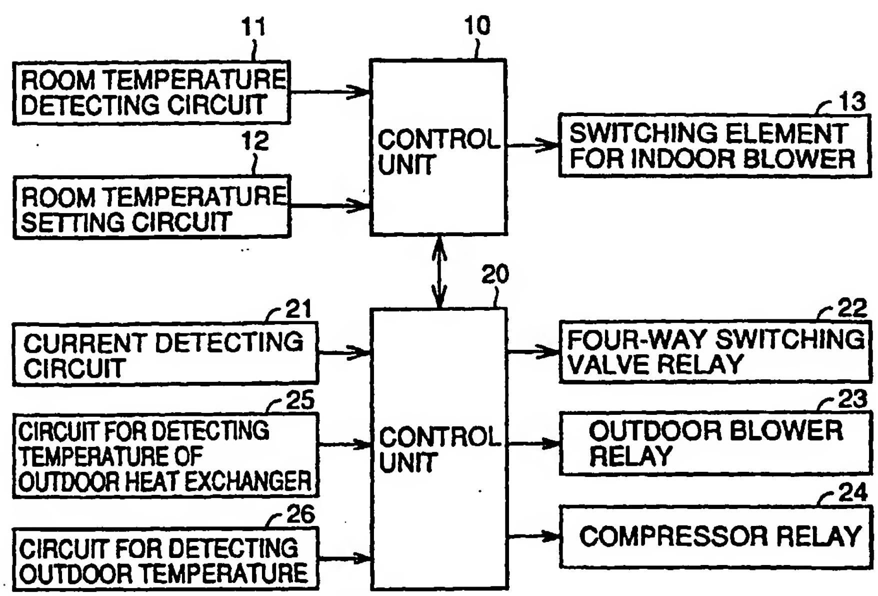

11
10
ROOM TEMPERATURE DETECTING CIRCUIT
12
ROOM TEMPERATURE SETTING CIRCUIT
CONTROL UNIT
13
SWITCHING ELEMENT FOR INDOOR BLOWER
20
21
CURRENT DETECTING CIRCUIT
25
CIRCUIT FOR DETECTING TEMPERATURE OF OUTDOOR HEAT EXCHANGER
26
CIRCUIT FOR DETECTING OUTDOOR TEMPERATURE
CONTROL UNIT
22
FOUR-WAY SWITCHING VALVE RELAY
23
OUTDOOR BLOWER RELAY
24
COMPRESSOR RELAY

FIG.3

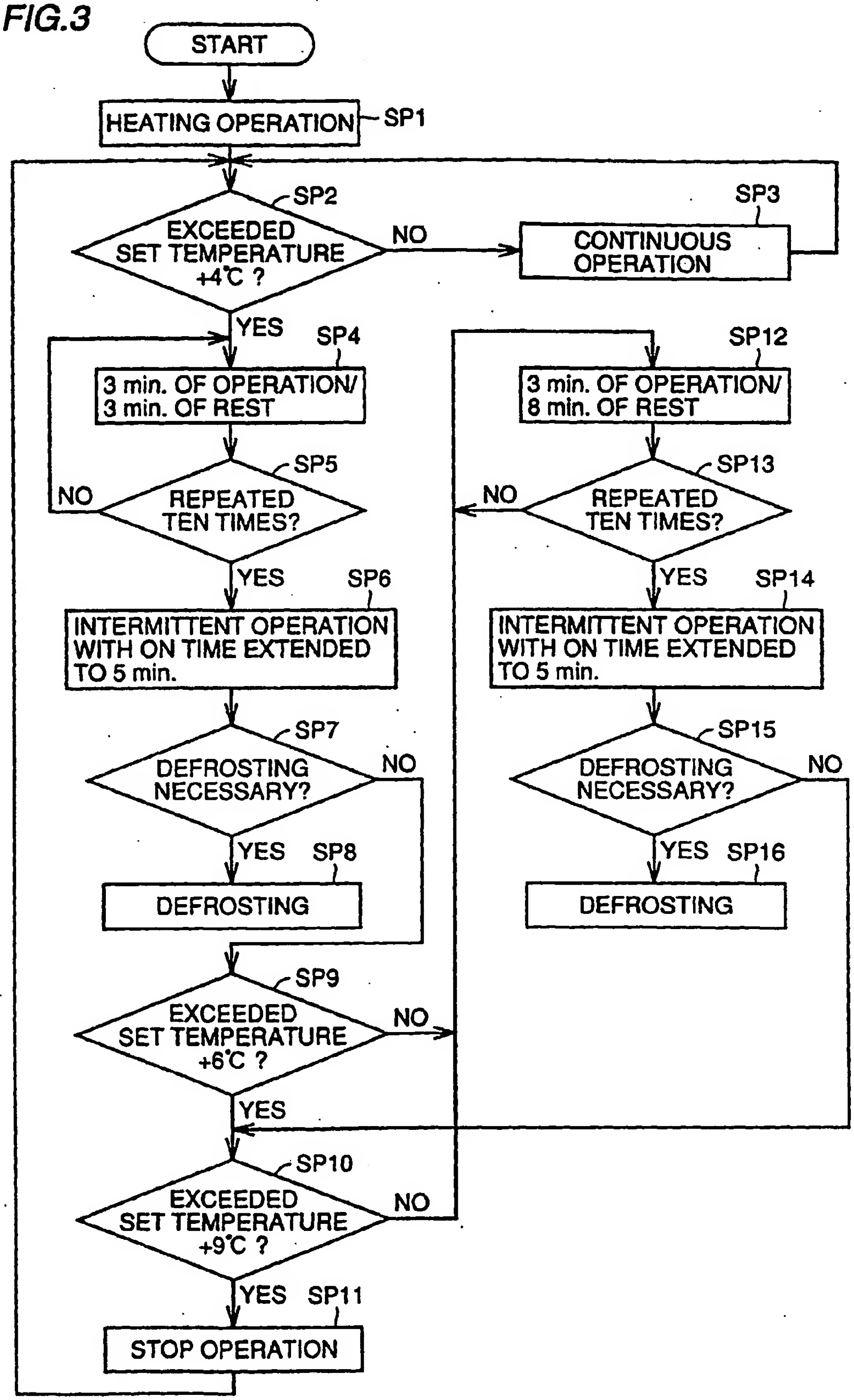

START
HEATING OPERATION
SP1
SP2
EXCEEDED SET TEMPERATURE +4℃ ?
NO
SP3
CONTINUOUS OPERATION
YES
SP4
3 min. OF OPERATION/ 3 min. OF REST
SP5
REPEATED TEN TIMES?
NO
YES
SP6
INTERMITTENT OPERATION WITH ON TIME EXTENDED TO 5 min.
SP7
DEFROSTING NECESSARY?
NO
YES
SP8
DEFROSTING
SP9
EXCEEDED SET TEMPERATURE +6℃ ?
NO
YES
SP10
EXCEEDED SET TEMPERATURE +9℃ ?
NO
YES
SP11
STOP OPERATION
SP12
3 min. OF OPERATION/ 8 min. OF REST
SP13
REPEATED TEN TIMES?
NO
YES
SP14
INTERMITTENT OPERATION WITH ON TIME EXTENDED TO 5 min.
SP15
DEFROSTING NECESSARY?
NO
YES
SP16
DEFROSTING

FIG.4

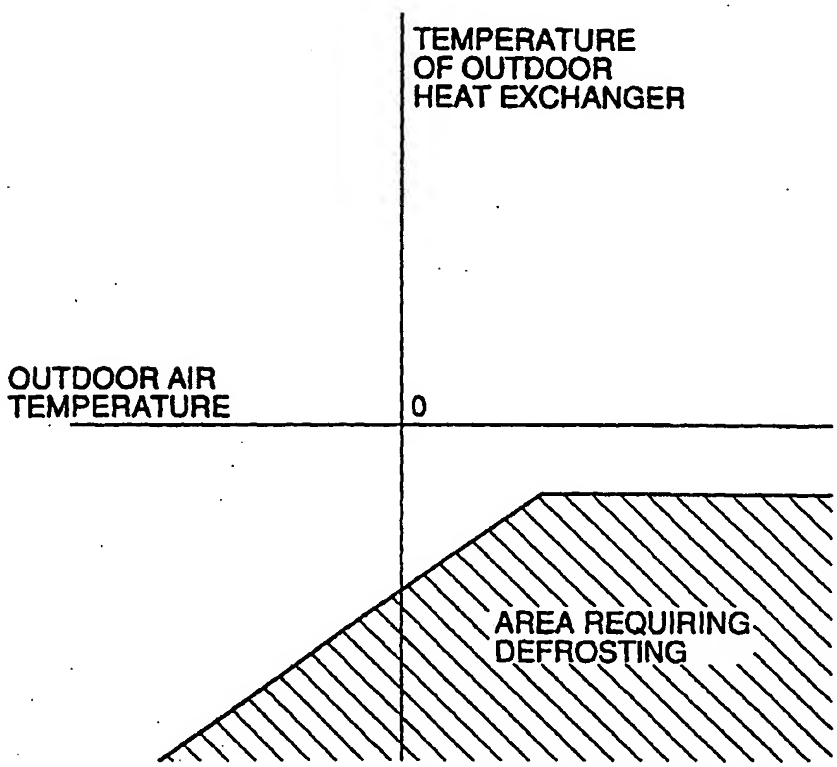

TEMPERATURE
OF OUTDOOR
HEAT EXCHANGER
OUTDOOR AIR
TEMPERATURE
0
AREA REQUIRING
DEFROSTING

FIG.5

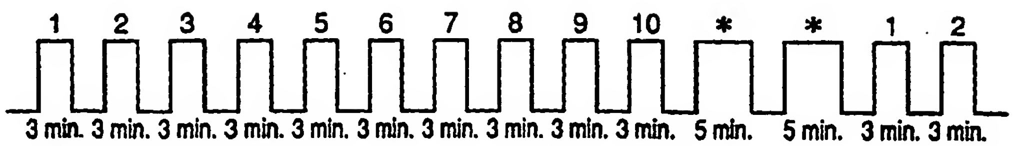

1
2
3
4
5
6
7
8
9
10
*
*
1
2
3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 3 min. 5 min. 5 min. 3 min. 3 min.

FIG.6

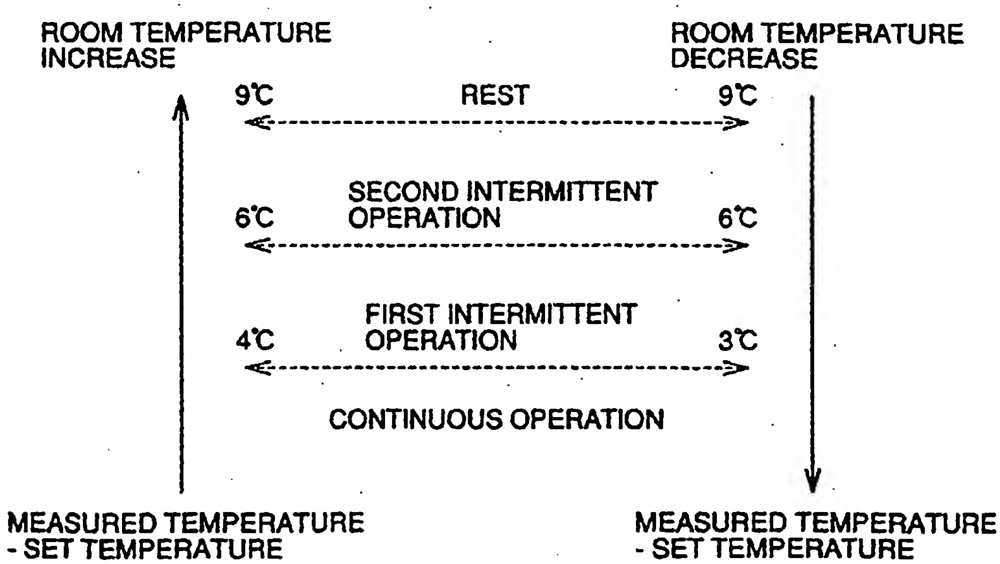

ROOM TEMPERATURE INCREASE
ROOM TEMPERATURE DECREASE
9℃
REST
9℃
6℃
SECOND INTERMITTENT OPERATION
6℃
4℃
FIRST INTERMITTENT OPERATION
3℃
CONTINUOUS OPERATION
MEASURED TEMPERATURE - SET TEMPERATURE
MEASURED TEMPERATURE - SET TEMPERATURE

FIG.7

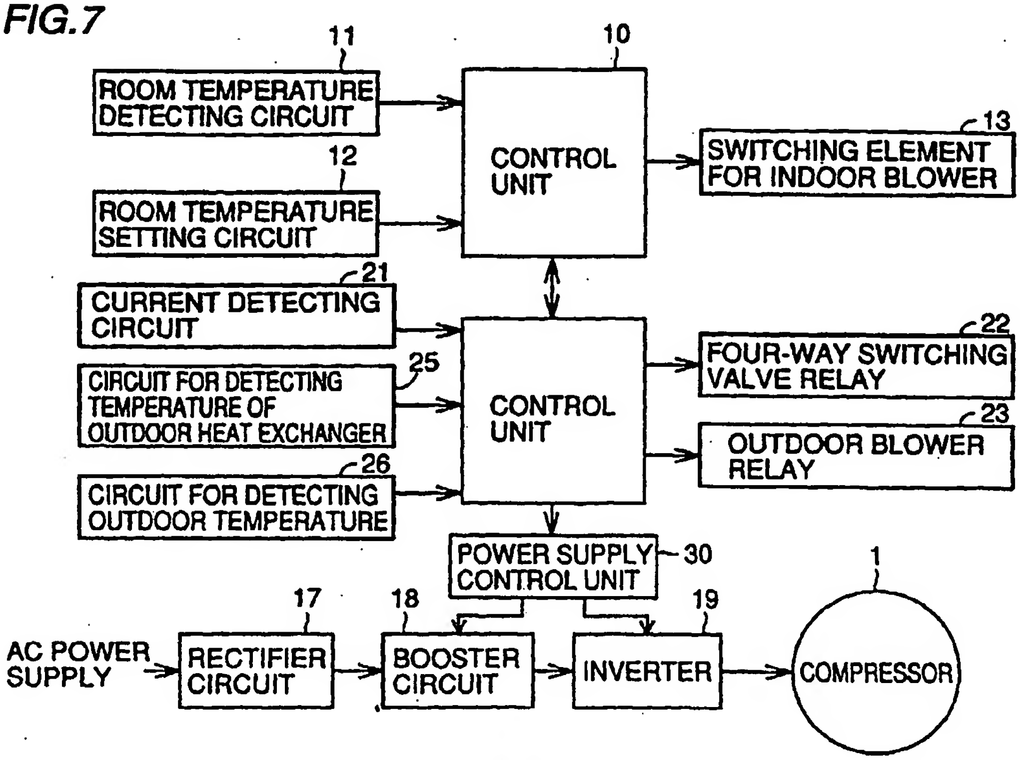

11
10
ROOM TEMPERATURE DETECTING CIRCUIT
CONTROL UNIT
13
SWITCHING ELEMENT FOR INDOOR BLOWER
12
ROOM TEMPERATURE SETTING CIRCUIT
21
CURRENT DETECTING CIRCUIT
22
FOUR-WAY SWITCHING VALVE RELAY
25
CIRCUIT FOR DETECTING TEMPERATURE OF OUTDOOR HEAT EXCHANGER
CONTROL UNIT
23
OUTDOOR BLOWER RELAY
26
CIRCUIT FOR DETECTING OUTDOOR TEMPERATURE
POWER SUPPLY CONTROL UNIT
30
1
17
18
19
AC POWER SUPPLY
RECTIFIER CIRCUIT
BOOSTER CIRCUIT
INVERTER
COMPRESSOR

FIG.8

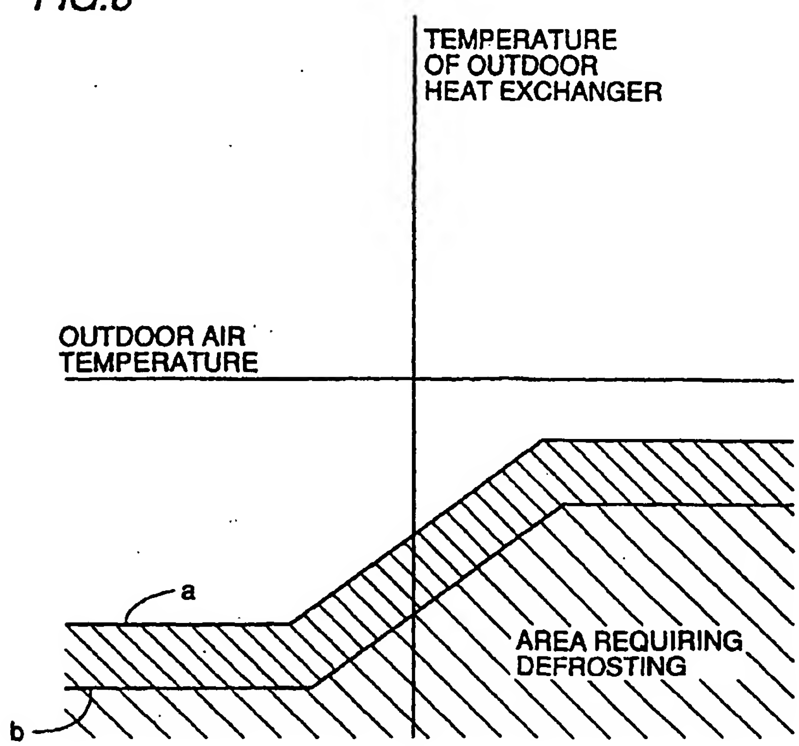
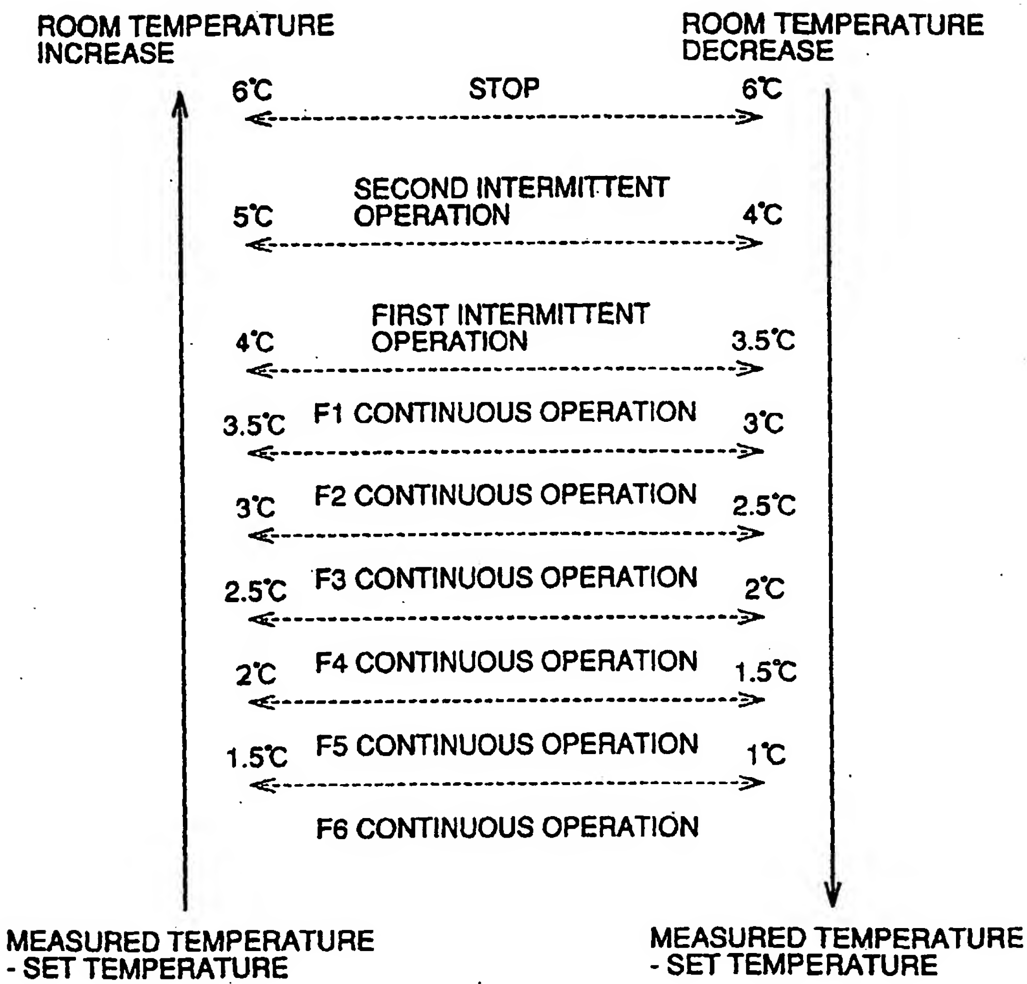

TEMPERATURE OF OUTDOOR HEAT EXCHANGER
OUTDOOR AIR TEMPERATURE
a
AREA REQUIRING DEFROSTING
b

FIG.9


ROOM TEMPERATURE INCREASE
ROOM TEMPERATURE DECREASE
6℃
STOP
6℃
5℃
SECOND INTERMITTENT OPERATION
4℃
4℃
FIRST INTERMITTENT OPERATION
3.5℃
3.5℃
F1 CONTINUOUS OPERATION
3℃
3℃
F2 CONTINUOUS OPERATION
2.5℃
2.5℃
F3 CONTINUOUS OPERATION
2℃
2℃
F4 CONTINUOUS OPERATION
1.5℃
1.5℃
F5 CONTINUOUS OPERATION
1℃
F6 CONTINUOUS OPERATION
MEASURED TEMPERATURE - SET TEMPERATURE
MEASURED TEMPERATURE - SET TEMPERATURE